Mining Matters for Nova Scotia '99 - Opportunities for Economic Development

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Opportunities for Economic Development: Creation of a High-quality Learning Experience at the Fundy Geological Museum

by ***K. Adams***, Fundy Geological Museum, Two Islands Road, Parrsboro, Nova Scotia B0M 1S0

The Fundy Geological Museum, located on the Glooscap Trail in Parrsboro, is operated by the Cumberland Geological Society as a part of the Nova Scotia Museum. The museum provides exhibits and interpretive programs based on the geological resources of the Bay of Fundy and northern Nova Scotia. Operating revenues are generated through admissions, gift shop sales, programming fees, employment grants, Nova Scotia Museum grants, personal and corporate donations, and special events (Nova Scotia's Gem and Mineral Show). The site directly contributes over $ 300,000 annually to the local economy in the form of salaries and purchases of goods and services.

The facility provides a focal point for people to learn about the region's tremendous paleontological and mineralogical treasures and offers visitors self-guided gallery tours, audio-visual presentations, interpretive programs, beach tours, hands on activities, and a variety of temporary exhibits. The museum has attracted 135,000 visitors from around the world, including 16,000 school and university students. The impact on the local economy of over 20,000 museum visitors annually is estimated to exceed $1,500,000.

The continued success of the museum is crucial to maintain this important economic and educational force in the community. The museum has identified a number of opportunities to expand its economic impact through increased first time and repeat visitation. Sources are now being pursued to secure the human and financial resources required to provide a high-quality museum experience. Corporate sponsorship, grants for tourism development and research, public fund raising, and local partnerships for co-operative marketing and product development all play a significant role in achieving the museum's goals.

How can new human and financial resources increase the museum's impact on the local economy and enhance the visitor's learning experience?

Example 1: Financial resources were acquired in 1999 through a Job Creation Partnership with Human Resource Development Canada (HRDC) to hire a fossil preparator and two assistants, with additional corporate funding from the Sable Offshore Energy Project, and seven student placements funded by the Young Canada Works in Heritage Institutions and HRDC and Economic Development and Tourism's student employment programs. These placements have led to the preparation of dinosaur material from the Wasson Bluff Special Place and amphibian material from a Joggins tree trunk, exciting additions to the museum's web site, development of several exhibits, public programming, a variety of media coverage, and the opportunity for museum staff to interact with researchers from sister institutions. These activities have helped increase public awareness of the museum's programs, resulting in a 3-4% rise in site usage in 1999 and maintaining a 20% increase noted in 1998.

Example 2: The public response to the activity in the Research Lab and the museum's programs confirms the widespread interest in dinosaurs and fossils. The Fundy Geological Museum has launched a "Buy-a-Bone; Replica Project" to create a new exhibit, a reproduction of a prosauropod skeleton. Mounted and installed, the skeleton will cost $24,500 (US) and schools, corporations and individuals are being invited to help the museum purchase this display one bone at a time. The cost of sponsorship will range from ten dollars for a small bone, to several hundred dollars or more for a larger bone. Tax receipts are available for donations made to this project and donors contributing $150 or more will receive a fossil replica of an ***Otozoum*** footprint from the Research Lab. The skeleton will be the only one of its kind in the Atlantic Provinces. The anticipated impact of this exhibit is an additional 3-5% increase in annual museum visitation over the next five years.

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Geological Interpretation of Northeastern Nova Scotia with Radarsat S2 Beam Mode

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Eight Radarsat Standards Beam Mode (S2) images of central Nova Scotia and the Cape Breton/Antigonish area were utilized to produce a seamless mosaic of approximately 75% of Nova Scotia. Orthorectification and histogram matching, as well as the selection of natural morphological and geological features on adjacent imagery, were used to produce this regional mosaic with a uniform tone. Ocean features, which revealed speckles and heterogenous tone on imagery, were clipped with the help of a 1:50 k Digital Elevation Model (DEM) of Nova Scotia using an original spatial modeling function. Filter analysis of imagery, including Gamma, Frost, Lee and Mean filters, were experimented with to select the most applicable filter enhancement in order to suppress speckles inherent in radar imagery. The Lee filter enhancement provided an effective means to examine geological features and hence was applied to smooth the regional mosaic and detect large scale geological features. Value-added products were created through the integration of Radarsat imagery with digital geological maps, a DEM, and Landsat imagery. It was concluded that these products enhance the detection and interpretation of structural features which may be associated with mineral emplacement.

In general, a variety of lineaments were observed on the Radarsat mosaic, which help the geological mapping of the region and interpretation of the geological framework of the area. Specifically, a graben and synform located in the Whycocomagh Basin of Cape Breton Island are easily identified on the Radarsat imagery. The graben seems to be dissected with linear features; a dome-shaped structure can be observed in the northeast part of this graben. As well, major faults such as the Hollow Fault in the Antigonish area and the Aspy Fault in the Cape Breton area are mappable on the Radarsat imagery. Granitic plutons of the Canso - Guysborough area can be delineated on the Radarsat imagery due to their smooth texture and medium tone; these features, as well as the metasedimentary rocks which separate them or occur in their vicinity, are easily delineated on value-added products.

This study indicates that Radarsat imagery is very useful for discerning structural features and may reveal the existence of targets suitable for further geological investigation and modeling pertaining to mineral emplacement.

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Geological Map of Wolfville and Windsor, NTS 21H/01 and part of 21A/16, Hants and Kings Counties, Nova Scotia

by ***R. C. Boehner***, ***R. G. Moore***, and ***C. M. Kennedy***

A preliminary geological map (1:50 000 scale) of the Wolfville and Windsor area (NTS 21H/01 and part of 21A/16), Hants and Kings Counties, Nova Scotia, is displayed as an update of map 1128A by Crosby published by the Geological Survey of Canada in 1962. The new map is a compilation of recent geological mapping (1980s to 1990s) undertaken at a variety of scales by Dr. R. G. Moore, L. J. Ham and the late Dr. S. Ferguson. It is intended to accompany a report on the geology of the western part of the Windsor (Kennetcook) Carboniferous Basin in preparation by R. G. Moore. The map area is unique and significant because it includes most of the major rock units that constitute southern mainland Nova Scotia. These include: the Cambrian to Devonian metasedimentary and metavolcanic rocks in the Meguma Terrane, middle Devonian granitoid rocks of the South Mountain Batholith, sedimentary rocks of the Windsor Basin, and the Mesozoic Fundy Basin sedimentary and volcanic rocks. Intact unconformities of successive upper Paleozoic and lower Mesozoic basin fills are well represented. The map area, furthermore, contains type and reference sections for many of these rock units (e.g. the lower to middle Paleozoic White Rock, Kentville and New Canaan formations, stratigraphically above the Goldenville and Halifax formations of the Meguma Group, the lower Carboniferous Horton and Windsor Groups, as well as the Wolfville, Blomidon, North Mountain and Scotts Bay formations of the Mesozoic Fundy Group).

Figure: (not presently available)
Figure 1. Simplified cross-section showing geological map units in the Wolfville - Windsor area.

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A Spatial and Statistical Interpretation of Water and Vegetation Surveys, Southwest Cape Breton Island

by ***J. L. Buckle***, Department of Earth Sciences, University of Ottawa, Ottawa, Ontario K1N 6N5, ***G. Bonham-Carter***, and ***G. Hall*** Geological Survey of Canada, Ottawa, Ontario K1A 0E8

A multimedia geochemical data set, collected in southwest Cape Breton Island, was spatially and statistically

analyzed to enhance the geochemical understanding and to evaluate the mineral potential of the area. The data sets, which include stream water and balsam fir twig surveys, were integrated and analyzed in the SPANS GIS and SPLUS statistical package.

Southwest Cape Breton Island is a major region of mineral exploration in Eastern Canada. The study area is located within the Avalon terrane, and consists of Precambrian sedimentary and volcanic rocks and overlying Cambrian-Ordovician shales and sandstones. The region has been the subject of significant exploration interest as a result of numerous Cu, Pb, Zn and Au occurrences. Data analysis techniques, including catchment basin and regression analysis, enable a more comprehensive understanding of the area.

In this study each data set was statistically analyzed and subsequently compared to identify correlations between the two data sets. A catchment basin approach, using a geographic information system (GIS), was used to link the water geochemistry to the underlying bedrock geology. Scatter plots of each element reveal important controls by pH and Fe/Mn, and box and whisker plots show the influence of lithology. The lithologic control of water geochemistry is also revealed through the regression of each element on the aerial proportion of rock type within a catchment. The results from this study show that multimedia data sets can be effectively used to add to the knowledge base of the study area and aid in the location of new mineral occurrences.

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On the Nova Scotia 'Fossil Trail': Opportunities and Emerging Issues of Community-based Economic Development

by ***J. H. Calder***, jhcalder@gov.ns.ca

Nova Scotia has been blessed with two complementary phenomena of geology and geography that endow rural communities today with a rich fossil heritage. Firstly, Nova Scotia in the past was a key area wherein the early evolution of life on land was played out and preserved in the rock record. Secondly, our maritime geography today with our dramatic coastal cliffs and tides ensure that this fossil record continually comes to light. The opportunity that this provides is the focus of a project, formally implemented in 1996, co-ordinated by the Nova Scotia Department of Natural Resources and working with community development agencies across the province.

The Cumberland Regional Economic Development Agency (CREDA), Colchester Regional Development Agency (CoRDA), and New Deal Development of Sydney Mines and surrounding area have all made significant progress in the past year in realizing their own particular visions of economic benefit from the fossil heritage in their respective communities. As these individual projects proceed, issues of common goals, complementary strategies, and protection of the fossil heritage emerge. The provincial departments of Economic Development and Tourism and Culture have dual roles to play in assisting communities to seize the opportunity of sustainable economic development while at the same time maintaining the integrity of our world-class fossil resources for all Nova Scotians. The current challenge is to provide a provincial vision and leadership while simultaneously supporting community entrepreneurship. Less tangible, perhaps, but nonetheless important is the opportunity for former mining towns and villages whose traditional resource base has been exhausted to regain a sense of pride and hope for the future.

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The Nova Scotia Prospectors Assistance Program - Helping to Find Tomorrow's Mines

by ***H. V. Donohoe***, hvdonoho@gov.ns.ca, ***R. F. Mills***, rfmills@gov.ns.ca, ***P. D. McCulloch***, mccullpd@gov.ns.ca, and ***M. A. MacDonald***, mamacdon@gov.ns.ca

A fundamental component of a successful mineral exploration industry is a "community" of prospectors. These people are the grass roots of the mineral industry because they are searching for new deposits and carrying out exploration on known mineral occurrences. Their work makes these occurrences attractive to investors and senior mining professionals. Although prospectors have always been an important part of mineral exploration, in recent years their importance has increased. Over the past decade most major and intermediate mining companies have reduced their level of direct exploration activity. Companies now rely on prospectors and other exploration professionals to bring them properties for further development.

The success of Nova Scotia's prospectors has grown steadily over the years. Success is measured not only by mineral deposit discoveries but also by the number of mining company visits to Nova Scotia properties and the interest they show in the province at major trade shows. Part of this success is due to the encouragement of prospectors through courses and financial assistance. Since the start of federal-provincial mineral development agreements in the mid-1980s, money has been earmarked for prospector assistance.

Today the present Prospector Assistance Program receives its funding from the Canada-Nova Scotia Cooperation Agreement on Economic Diversification, which is administered jointly by the Nova Scotia Department of Economic Development and the Atlantic Canada Opportunities Agency (ACOA). The agreement has a value of $600,000 over four years and provides the support and encouragement necessary to ensure that the growth of prospecting continues.

The Prospector Assistance Program has three components:

1. prospector training,
2. prospector assistance, and
3. marketing assistance.

Although each component is independent of the others, all three are integrated in a uniform approach to encouraging the development of the province's mineral potential.

Prospector training provides support for training entry level prospectors in different locations throughout Nova Scotia. An advanced course is offered as demand indicates and gives additional experience to those prospectors graduated from the basic course. More than 230 students have taken the training courses.

Financial assistance for prospectors under the second component provides a base level of support for individual prospectors to search for new mineral deposits and attract exploration activity by larger companies. During the 1998 and 1999 calendar years, 50 prospectors have received financial assistance for work on their properties.

The marketing of a prospector's mineral property is aided by the third component of the PAP. National and international trade shows provide an unparalleled opening to present Nova Scotia's mineral potential and investment opportunities to mining companies and industry representatives. Marketing assistance provides financial assistance to travel to trade shows, display information and samples about properties, and make contacts with industry people. Thirty-five prospectors have travelled to trade shows to promote their properties and encourage investment in Nova Scotia.

Prospector assistance is a long term commitment to a stronger mineral industry. When new mines are brought into production, this investment is paid off in employment and wealth generation.

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Re-interpretation of the Geology of the Cape Breton

Highlands Using Combined Remote Sensing and Geological Databases[1]

by ***M. Ethier, S. M. Barr, R. P. Raeside***, Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0, and ***T. L. Webster***, Centre of Geographic Sciences, Lawrencetown, Nova Scotia B0S 1M0

The Cape Breton Highlands are underlain by rocks which range in age from more than 1200 Ma to less than 360 Ma, and display a wide range in composition. Relationships among these varied rocks, as revealed by geological mapping, are not everywhere clear, in part due to limited exposure and also to difficulty of access in many areas. A large geological database exists for the highlands, based on detailed mapping, much of it at 1:10 000 scale, during the 1980s by faculty and students at Acadia University and, in the western highlands, Dalhousie University. A variety of remotely sensed data also exists, including Radarsat S7 and S2 scenes, Landsat TM and orthorectified air photo mosaics. Digital topographical, geological, and geophysical GIS layers can be incorporated with the above imagery.

The goal of this study is to integrate the geological and remote sensing databases, and use the results to evaluate the various geological interpretations of the highlands. A key goal of the study is to improve on the geological interpretations, in particular with respect to the distribution of major faults and postulated terrane boundaries. The results will have implications for terrane correlations and tectonic evolution models for the northern Appalachian orogen, and also for mineral exploration. Gold occurrences, for example, are known to be associated with a major fault zone in the central highlands, but the extension of the fault to the south is poorly resolved.

[1]Funded by a Natural Sciences and Engineering Research Council Grant to S. M. Barr

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Stratigraphy and Structure in a Section of the Halifax Formation, Black River, Kings County, Nova Scotia[1]

by ***K. Gladwin, S. M. Barr***, and ***A. S. Macdonald***, Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0

A recently constructed canal adjacent to Black River provides an excellent opportunity to examine the upper part of the Halifax Formation in a continuously exposed section over 1 km in length. The canal has vertical walls ca. 5-10 m in height, and is part of the Black River hydroelectric system. It trends north-south, approximately perpendicular to strike in the formation. More intermittent exposures in Black River and adjacent roadcuts continue the section north 500 m to the quartzite that marks the base of the White Rock Formation, and 7 km south to the contact with the South Mountain Batholith. The purpose of this study is to examine the section in detail and divide the formation into lithologic units to compare them to those described by previous workers in the Meguma terrane. Structural studies will check for folding and faulting in the section. Petrographic and chemical studies will also be done of mafic sills in the section to determine their chemical character and hence the tectonic setting of their emplacement. Preliminary examination indicates that at least four distinct lithologic units are present, varying in their sand/silt/mud ratios. Cleavage is steeply dipping and does not appear to vary significantly in orientation through the section. Bedding is generally more shallow in dip than cleavage, and evidence for folding was not obvious in the preliminary examination. Quartz and quartz-carbonate veins and lenses are abundant in the section.

[1]Funded by a Natural Sciences and Engineering Research Council Grant to S. M. Barr

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Musquodoboit Batholith Project Activities

by ***L. J. Ham***

Two Open File geological maps (1:50 000 scale) of the Devonian Musquodoboit Batholith were completed and released in 1999. This batholith, the second largest (approximately 800 km^2) of mainland Nova Scotia and the Meguma Terrane, is located in south-central Nova Scotia and has been the subject of a recent study which compares and contrasts it with the larger (approximately 8000 km^2) South Mountain Batholith of southwestern Nova Scotia. The two batholiths have numerous similarities (mineralogical, petrological, geochronological, geochemical).

The batholith covers portions of three 1:50 000 NTS map sheets, 11D/13, 11D/14 and 11D/15. Field mapping was undertaken on 1:10 000 scale maps, and information was digitally compiled on bases of the same scale using the FIELDLOG® computer-based mapping program. The final products of the project are two 1:50 000 scale maps (11D/14 and 11D15) and two 1:10 000 Open File Maps covering the portion of the batholith underlying 11D/13. These latter two Open File Maps were released in 1998 (Feetham et al., 1998; Horne et al., 1998).

The Musquodoboit Batholith was mapped using the terminology and methodology of the South Mountain Batholith. The rocks are grouped into four map units ranging from biotite monzogranite to leucogranite. The majority of the batholith is composed of medium- to coarse-grained biotite (with some muscovite) leucomonzo-granite (biotite content average 6%), with more biotite-rich monzogranite (biotite content up to 10%) concentrated at or near the metasedimentary/granitic rock contacts. In the western portion of the batholith (11D/13 and 11D/14), the rocks contain appreciable amounts of cordierite (up to 4%) with trace amounts visible throughout the rest of the batholith. Individual bodies of specialized granites (with increased amount of muscovite; texturally different units comprising fine-grained rocks, those with porphyritic textures, those with variable textures ranging from fine-grained to porphyritic) were outlined during the mapping and enhanced by geophysical radio-element work of Ford (1991).

Contacts with the surrounding Meguma Group rocks were incorporated both from Faribault's early work in the late 1800s and geophysical interpretation of King (1997), who produced maps of enhanced, second vertical derivative aeromagnetic data. Drillholes and mineral occurrences were also compiled on the 1:50 000 maps.

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Eastern Shore Compilation Project

by ***L. J. Ham*** and ***P. K. Smith***, pksmith@gov.ns.ca

Work began in earnest on the Eastern Shore compilation project this past summer with two staff members dedicated to the project. The goals of the project are to compile existing information on the gold districts and surrounding areas of the Eastern Shore, to incorporate all relevant information in a digital base and produce databases attached to the digital base, and to write individual deposit reports on selected gold districts. Geological maps were produced early in the 19thcentury by E. R. Faribault, and there was subsequent work by Malcolm in 1929. Since that time over the last century, and particularly in the recent past, there has been considerable work undertaken by various mineral exploration companies, prospectors, universities and other parties. There is a wealth of information on file with the Nova Scotia Department of Natural Resources (NSDNR), in private research files, and in internal company reports.

This initial work on the project involved NTS map areas 11F/03, 04, 05 and 06 and included field visits to the gold districts and mineral occurrences on the latter three areas. Map area 11F/03 has no significant mineral occurrences. This field work included site visits to the gold districts of Country Harbour, Upper and Lower Seal Harbour, Isaacs Harbour, Wine Harbour (all of 11F/04), Forest Hill and Mile Lake (11F/05) and the tungsten showing at Lazy Head (11F/06), in addition to visiting numerous smaller showings and occurrences of various commodities on NTS map areas 11F/04, 05 and 06.

Initial work from the mapping component of the project has involved compiling base maps for the four NTS map sheets using ArcView®. Extensive work over the summer involved using both the NSDNR Mineral Occurrence and Drillhole databases, and incorporating the location of all the mineral occurrences and drillholes from these databases in the new digital bases. These locations of mineral occurrences and drillholes were individually checked, and subsequently re-located, by researching the assessment files where the original locations are recorded.

Geological information, including cross-sections, mine plans and other relevant information, will next be incorporated into the digital base maps and databases.

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Nova Scotia Zeolite - A Global Perspective

by ***L. E. W. Hogg***, C_2C Mining Corporation, 11 Calkin Drive, Unit 2, Annapolis Valley Industrial Park, Kentville, Nova Scotia B4N 3V7

The use of zeolite minerals continues to grow around the world. This growth is in response to the world's needs for more and more earth materials. New and advanced technologies are currently being developed and utilized at a phenomenal rate and are affecting all aspects of life worldwide. Nova Scotia zeolites are unique in the world and can provide solutions in new and current technological applications, thereby securing a leading position in the global marketplace.

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The Land-use Group: Providing Geoscience Information to Support Sustainability in our Communities and the Environment

by ***D. B. Hopper*** and ***F. J. Bonner***

The Land-use Group consists of a planner-geologist team committed to identifying, planning and implementing innovative ways to integrate geoscience information with environmental and community planning. Staff encourage an anticipatory approach to planning and decision-making in balancing environmental and societal needs. The group's main role is to improve the availability and increase the use of geoscience information by other provincial government departments, municipalities, community economic development groups, land owners and land-use and environmental planners.

The use of geoscience information in community and environmental planning has two direct benefits:

1. helps to identify economic development opportunities through mineral exploration, mining, reclamation and geotourism; and
2. helps to prevent the loss of value in land and property due to hazardous geological conditions (geohazards).

The business of exploring and extracting minerals continues to be economically important to Nova Scotia. It provides new wealth for the province, jobs in rural areas and direct benefits to communities. Every stage of the mining sequence, which includes exploration, mining, secondary processing and reclamation, can bring prosperity to communities.

Reclamation not only generates economic benefits for local communities but is also environmentally beneficial. Mining companies and communities have the potential to form co-operative linkages to determine the future use and benefits of mined land. With proper planning, used and abandoned mine sites can be turned into community parks, for example, or restored back to a natural state with re-established ecosystems and habitats. The possibilities of adding value to the land and surrounding properties are only limited by imagination.

The Land-use Group has begun a new project called the "Surface Mines and Reclamation Project." The main objective is to identify abandoned surface mine sites, particularly those with unsafe and/or poor environmental conditions and find ways to reclaim them to benefit land owners and local communities. So far the Land-use Group is involved in two specific projects which involve the reclamation of abandoned acid-producing slate pits using a "remediation mix" derived from clean construction and demolition waste materials. We believe this is an innovative approach to mine site reclamation, one that supports the objectives of the province's solid waste management strategy and the principles of sustainable development.

Geoscience information is vital in land development decisions, although it has not been used to its full potential by planners and developers. When geoscience is properly considered in the planning process the subsurface issues (including potential resources and hazards) are being integrated with surface planning issues, which gives us a more complete view of the physical environment in which we live. For example, the identification and protection of suitable gravel deposits in proximity to developing communities will reduce costs to local builders. Preventing residential development over geological terrain prone to subsidence will avoid the loss of property values and high insurance costs.

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Preliminary Geology of the Weymouth and Church Point Areas, Nova Scotia

by ***R. J. Horne***, rjhorne@gov.ns.ca, ***C. E. White***, whitece@gov.ns.ca, ***C. Muir***, and ***M. Young***

Geological mapping of the lower to middle Paleozoic bedrock units in the Weymouth and Church Point areas (NTS 21A/05, 21B/08), southwestern Nova Scotia, is a continuation of a multi-year mapping project initiated in the Digby

area in 1998. The map area generally has low topographic relief and is largely covered by extensive till sheets, mainly of local origin. Bedrock exposure is generally sparse, with good exposure limited to the Sissaboo River and a few coastal sections along St. Marys Bay.

The lower to middle Paleozoic units in the map area include the Goldenville and Halifax formations of the Meguma Group and the younger White Rock and Torbrook formations. The lower Goldenville Formation consists mainly of metasandstone and lesser cleaved metasiltstone with minor slate; well exposed sections indicate significant variation in the ratio of metasandstone and metasiltstone. Relatively coarse sandstone and fine conglomerate occur in the northwestern part of the area, along St. Marys Bay. Towards the top of the formation a locally well cleaved, laminated metasiltstone occurs that is tentatively correlated with the Bloomfield member exposed to the north. Calc-silicate concretions and thin beds are abundant. The Halifax Formation has been subdivided into two units. The lower unit consists of dark slate with minor sulphide minerals and thin sandstone beds. This unit is similar to the Cunard unit exposed elsewhere in the Meguma Group. The upper unit consists of well laminated slate and metasiltstone with alternating thin beds of dark slate and light, cross-laminated metasiltstone. This unit may be equivalent to the Bear River member. The White Rock Formation consists of thick quartzite beds and laminated, marly metasiltstone and may be in faulted contact with the Halifax Formation. The Torbrook Formation overlies the White Rock Formation and consists of fossiliferous metasiltstone. Mafic sills are not abundant and were only observed in the northeastern part of the map area.

The lower to middle Paleozoic rocks are regionally metamorphosed to biotite facies and are deformed into regional, northeast- to north-northeast-trending, moderately plunging folds with axial planar cleavage. Locally, a pronounced stretching lineation defined by elongate quartz clasts and mud chips is developed parallel to the fold hinge. A northeast-trending dextral, strike-slip shear zone occurs within the lower Halifax unit, near the boundary between the Goldenville and Halifax formations. It is defined by a crenulation cleavage, which deforms regional axial planar cleavage, and mesoscale folds. A northeast-trending, northwest-dipping thrust fault occurs near Weymouth, where bedding cleavage relations imply southeast-directed thrusting of a fold hinge onto a steep limb. One north-trending brittle fault with a dextral strike-slip component of displacement was observed.

The ca. 370 Ma South Mountain Batholith and Clayton Hill Pluton intrude the lower to middle Paleozoic rocks and produce contact metamorphic aureoles characterized by hornfels with biotite, cordierite and andalusite porphyroblasts. A small mafic intrusion occurs near the northern part of the map area.

New mineral occurrences recognized include:

1. quartz ± molybdenite ± chalcopyrite veins, mineralized greisen and disseminated mineralization in boulders throughout the Clayton Hill Pluton;
2. skarn mineralization in Goldenville Formation concretions;
3. quartz ± pyrite veins as boulders and in bedrock within the shear zone in the lower unit of the Halifax Formation and field relations suggest syn-faulting vein emplacement.

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Application of Combined Enhanced Aeromagnetic and Digital Elevation Data in the Geological Interpretation of the Eastern Meguma Terrane

by ***M. S. King***, and ***R. J. Horne***, rjhorne@gov.ns.ca

Aeromagnetic and digital elevation data are useful for regional geological interpretation. Combining these data can further enhance geological features, allowing for interpretation beyond that from the individual data sets. Enhanced

aeromagnetic data, consisting of calculated second derivative data, have been overlain on detailed digital data, generated from 1:10 000 topographic data, to create a single map image for the eastern Meguma Terrane. Both data sets were gridded to 75 m. Colour contour information was generated from the magnetic data, whereas the digital elevation is presented as shaded relief, or textural, information. Illumination for the shaded relief layer is from the south (180 degrees) at 35 degrees from the horizontal.

The combined aeromagnetic and digital elevation data reveal useful and interesting features that enhance the geological interpretation of the eastern Meguma Terrane, in particular the structure and stratigraphy of the Meguma Group. For example, the digital elevation data commonly imply a more complex, composite pattern for regional northwest-trending faults than is apparent from offset of aeromagnetic features alone. In addition, numerous previously unrecognized northwest-trending faults and a few regional-scale northeast-trending faults are apparent. Linear features defined by the digital elevation data which cut some plutons, or are coincident with their boundaries, may provide relative age relationships for some northwest-trending structures and may be useful in interpretation of pluton emplacement. Locally, linear features in the digital elevation data highlight bedding-parallel ridges in the Meguma Group which enhance the magnetostratigraphy in areas of low magnetic relief.

Combined aeromagnetic and digital elevation data clearly provide a useful tool for geological interpretation of the Meguma Terrane. It should be stressed that this map image is a product of a single set of processing variables for the magnetic and digital elevation data. Changing these variables can provide considerably different images, each enhancing distinct geological features. Therefore, an interactive approach with the data is suggested.

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Geology of the Brookfield Barite Deposit, Colchester County, Nova Scotia

by ***D. J. Kontak***, kontakdj@gov.ns.ca

The Brookfield barite deposit, located 13 km southeast of Truro near the community of Brookfield, consists of high-grade, vein- and replacement-style barite zones within Carboniferous red siltstones and shales. The deposit forms part of the Carboniferous Zn-Pb-Ba-F metallogenic province on mainland Nova Scotia, along with other notable localities such as Gays River (Zn, Pb), Walton (Ba, Zn, Pb, Cu, Ag), and Smithfield (Zn, Pb, Ba). Although the deposit was discovered about a century ago, and has been mined for the past 15-20 years, there has been no detailed study of the deposit geology. During the past summer, the open pit was mapped in detail with the intent of ascertaining the lithological and structural controls on mineralization in terms of Carboniferous metallogeny.

The deposit area is located just south of the east-trending Cobequid-Chedabucto Fault System and north of the Rawdon Fault. Southeast of the deposit, the strata (060-090°/40-50°N) are grey to buff sandstones and siltstones with minor amounts of carbonaceous debris. Intercalated with these rocks are minor amounts of red siltstone. Toward the deposit area the strata change to red siltstone and shale which is generally the rock that hosts barite. Within the open pit area the stratigraphy is complex, as a result of several structural events, one of which pre-dates mineralization and two of which post-date it. The early event thrust strata toward the north along low-angle movement horizons, recognized as several centimetre thick fault gouge zones (mylonites?); these structures severely disrupted the stratigraphy. The next event, an east-trending fault zone, dominated the area and controlled the mineralization. The third structural event is recorded as block faults which offset the stratigraphy along a N-S axis such that the middle part of the deposit area is offset to the north relative to the east and west ends of the ore body. This latest event may have implications for exploration in the area.

Mineral paragenesis is dominated by barite, with minor siderite and trace quartz. The siderite occurs either at the contact of the barite and wall-rock sediments or as laminations within massive podiform lenses of barite, whereas quartz occupies open spaces within the crystalline barite. Barite occurs as:

1. massive, fine- to medium-grained, podiform barite of white to orange colour within the sediments;
2. small, mm- to cm-scale veinlets that define a halo about the deposit area;
3. ultrafine-grained orange barite; and
4. coarse (<10-15 cm), white crystals within zones several metres wide.

Type 4 barite dominates the deposit site and type 3 may represent recrystallization of earlier barite related to high-strain zones. Associated with the mineralization is wall-rock alteration (see photo below), manifested visually as a change in colour of the red sediment to blue-green. Whole-rock geochemistry is in progress to assess the nature of this alteration associated with the barite mineralization.

The above observations indicate that the Brookfield barite deposit represents structurally controlled, hydrothermal mineralization. Its relationship to the broad-scale Carboniferous metallogenesis (Zn, Pb, Ba, F) remains vague. Further work will evaluate this relationship, in addition to documenting mineralization with the deposit itself.

Figure: (not presently available)
Figure 2. Alteration envelope around sidierite-barite veins cutting red siltstones

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Observations on the Nature of Aplite-Pegmatite Sheets in the Peggys Cove-East Dover Area, Halifax County, Nova Scotia

by ***D. J. Kontak***, kontakdj@gov.ns.ca

The Peggys Cove-East Dover area is underlain by compositionally uniform, but texturally variable (i.e. medium- to coarse-grained, massive to layered, locally pegmatitic) biotite monzogranite that forms part of the aerially extensive, 370 Ma peraluminous South Mountain Batholith (SMB) of southern Nova Scotia. The presence of extensive coastal outcrop (i.e. >90%) in the study area provides an excellent locality to examine the nature of pegmatite-aplite sheets in the SMB, which locally dominates outcrops, in order to assess their potential for formation of gem pockets. Although pegmatites are known to occur throughout the SMB, there is little known regarding their generation and internal evolution, both of which are critical in terms of evaluating the potential for high-quality minerals such as tourmaline. As part of this study, an area of several kilometres, extending from just north of Peggys Cove southwards to East Dover, was mapped at 1:2000 scale on expanded areal photographs and all pegmatite-aplite occurrences noted. In several cases, detailed mapping of pegmatite-aplite sheets was done as a basis for subsequent geochemical studies, which are routine in assessing the degree of fractionation of pegmatites (e.g. K/Rb of K-feldspar).

The coastal exposures reveal the following general features of the magmatic rocks:

1. generally uniform texture of the monzogranite, but with local variations in the size (to 10-12 cm) and abundance (to 30-40%) of K-feldspar megacrysts;
2. large variation in abundance, size and texture of xenoliths;
3. localization of K-feldspar- rich pegmatite zones about some xenoliths;
4. extreme manifestation of magmatic layering in a single locality;
5. concentration of pegmatite-aplite sheets in a zone subparallel to the coast. Inland traverses were not successful in locating pegmatite-aplite sheets;
6. extreme variability in the vertical and lateral evolution of pegmatites and aplites.

Examination of the pegmatite-aplite sheets reveal:

1. welded contacts versus structural contacts between the sheets and host monzogranite. However, in one locality tourmaline fibres occur at the contact of sheet and host rock;
2. general zonation of line rock with contorted texture in the bottom half with a vertical coarsening of the leucocratic material and development of monomineralic K-feldspar layers in the upper part;
3. extreme lateral variability of zones;
4. formation of quartz-, muscovite- and tourmaline-rich pockets on variable scales;
5. generally flat dips which contrast with steep dips for fractures;
6. the sheets terminate as shear veins do, and may define en echelon arrays on both a small and large scale.

Initial geochemistry indicates the following:

1. aplites are silica rich (75-78 wt.% SiO_2), are potassic with $K_2O/Na_2O>1$, and have Rb=180 to 260 ppm, Sr<30 ppm, Nb<5 ppm, Sn<8 ppm;
2. bulk K-feldspar is Or_{72-80} with 250-350 ppm Rb and 120-190 ppm Ba;
3. perthitic feldspars consist of Or_{86-95} with <0.5 wt. % P_2O_5 and Ab_{96-100};
4. muscovite contains ca. 1-2 wt. % FeO and 0.4-1.0 wt.% MgO;
5. tourmaline is Fe-rich with Fe:Mg of 2:1 to 5:1.

These chemical indices generally indicate that the pegmatites are not extreme fractionates, but may instead represent local segregations of the host monzogranite. This does not preclude the fact that more extreme differentiates may exist.

Figure: (not presently available)
Figure 3. Tourmaline-rich cavity in pegmatite

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Physical Distribution of Zeolites in Basalt Flows of the North Mountain, Annapolis Valley Region, Nova Scotia

by ***D. J. Kontak***, kontakdj@gov.ns.ca

The Jurassic (ca. 200 Ma) North Mountain Basalts of the Bay of Fundy are world renowned for their zeolite minerals, with the variety mordenite [$(Ca, Na_2, K_2)Al_2Si_{10}O_{24}7H_2O$] having its type locality at Morden, Kings County. Although the occurrence and geographical distribution of zeolites have been known for more than a century, there is no thorough documentation of the distribution of zeolites within the flows. Given recent exploration endeavours to prove possible reserves and develop a commercial zeolite operation in the area, the need for such a description is timely. During the past summer, coastal localities were examined from Scots Bay to Digby in order to assess the local and regional controls on zeolite distribution within basalt flows. Based on field work covering ca. 15-20 km length of basalt exposure, a four-part classification scheme is described. Relevant to this project is the observation that zeolite-bearing flows may either be overlain or underlain by apparently pristine, zeolite-free basalt flows.

The four part classification for the zeolite flows is given below.

- Zone 1: a ***basal zone*** in contact with underlying flow (barren or zeolite-bearing) with disseminated zeolite or zeolite within vertical to dipping pipe-shaped vesicles of approximately 10-15 cm. This zone is overlain by barren, massive basalt.
- Zone 2: ***bubble-train zone*** with zeolites infilling spherical- to elliptical-shaped (in cross-section), vertically

oriented pipes of approximately 10-15 cm width and 1.5-2.0 m height.

- Zone 3: ***net-textured zone*** in which coalescing of vesicles occurs and density of zeolites increases.
- Zone 4: ***upper zone*** in which the greatest percentage of zeolites are concentrated. In addition, zeolites also occur within veins (fault zones ?) of variable vertical (to 8-10 m) and lateral (unknown because of exposure) extent.

The four-part zonal classification of the zeolites reflects the distribution of gas within the basalt flows at the time of solidification of the basalt with subsequent infilling of the cavities by zeolites. The presence of massive, zeolite- and vesicle-free basalt flows within the sequence is intriguing, with several possible explanations being investigated (e.g. eruptions from different magma chambers, degassing of a single, zoned chamber).

In addition to the zeolites, the nature and distribution of silica veins is being investigated to determine the relationship between these veins and zeolite mineralization. Silica veins dominate in the eastern part of the study area and are locally observed to show mutually cross-cutting relationships with zeolite veins.

Figure: (not presently available)
Figure 4. Bubble-train and net-textured zones in basalt

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Geological Investigations of the Coxheath Cu-Mo-Au System, Cape Breton Island, Nova Scotia: Structurally Controlled Porphyry-type Mineralization

by , ***D. J. Kontak*** kontakdj@gov.ns.ca, and ***J. DeWolfe***, Department of Geological Sciences, St. Mary's University, Halifax, Nova Scotia

The Coxheath Cu-Mo-Au mineralized system occurs within a Late Precambrian (620 Ma) volcanic-plutonic complex which underlies the Coxheath Hills area southwest of Sydney. The mineralized area was exploited for its high-grade copper veins (ca. 10% Cu) in the early part of the 19thcentury, but exploration activity since the 1980s has focused on its potential as a low-grade Cu-Au system. The deposit area has been noted for the past 25 years as an anomaly in the Canadian Appalachians because of its porphyry-style mineralization, recognized by the strong spatial association of the mineralized veins with localized potassic alteration within an extensive zone of propylitic alteration. The deposit area is also known for the spatial association of copper mineralization with tourmaline alteration.

Previous geological work in the Coxheath area includes regional and detailed mapping, geochemical studies of the host rock and mineralized zones, and some mineralogical investigations. The present study focuses on integrating earlier work with detailed investigations of vein structure (i.e. orientation, abundance, relative age and origin), mineral paragenesis and geochemical studies of the host rocks and alteration. During the past summer, detailed work focused on the main mineralized areas and observations were made of all structural features, wall-rock alteration and relationship of mineralization to the aforementioned features. In addition, logging of drill core housed at the NSDNR core storage facility in Stellarton was completed. The mineralized zones occur within a compositionally uniform, fine- to medium-grained diorite in structural contact with its variably feldspar porphyritic volcanic carapace. With respect to the nature of the host rocks and mineralization, the following points are particularly noted.

1. Although red monzogranite occurs extensively as outcrops in the mineralized area, this rock type is considered a product of potassic alteration, as can be seen on a micro-scale bordering tourmaline-bearing veins, and not a primary magmatic lithology.
2. The rocks record a strong structural control of both alteration and mineralization. In places the mineralized

zones, which may approach 10-20 m width, are best described as sheeted vein systems (i.e. <10-15 fractures/10 cm) with a notable absence of crackle-breccia style veining which characterizes many porphyry systems. In areas of sheeted veins, silicification and/or potassic alteration have destroyed the primary nature of the host rock.

3. The rocks show pervasive development of propylitic alteration, which has also been observed by earlier workers. This alteration overprints all earlier mineralization and alteration down to the microscopic scale.
4. Brittle/ductile style of veining occurs with classic conjugate-shear veins.
5. All alteration types overlap with high strain zones (i.e. mylonitic textures).

Late flat-lying shears and fault zones are in-filled with carbonate and hematite (post-mineralization) and may not be related to the prior hydrothermal system. Preliminary electron microprobe work, both analysis and imaging, indicates the following mineralogical features:

1. formation of Ba-rich (i.e. to 3-4 wt. % BaO) patches within and bordering earlier end-member potassic feldspar where proximal to secondary muscovite and chalcopyrite;
2. presence of abundant hydrothermal rutile and associated Fe-Ti oxide phases; and
3. abundant secondary quartz intergrown with the potassic feldspar which gives the diorite the granitic texture seen in the field.

Our preliminary studies concur with those of earlier workers in noting that the Coxheath mineralization resembles some aspects of porphyry systems, most notably in terms of the alteration, but the mineralization bears a strong structural control and there is little evidence of textures that relate to fluid over-pressuring which characterizes many porphyry systems.

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Stratigraphy and Geochemistry of the White Rock Formation in the Yarmouth Area, Nova Scotia[1]

by ***L. A. MacDonald***, Department of Geology, Acadia University, Wolfville, Nova Scotia, Canada B0P 1X0

The White Rock Formation and Brenton Pluton in the Yarmouth area were mapped and sampled during the summer of 1998 as part of the Southwest Nova Mapping Project and as the basis of an M. Sc. thesis project at Acadia University. The purpose of the study is to update and re-evaluate previous petrological and geochemical studies of these rocks and to investigate relationships with other areas of the White Rock Formation.

The White Rock Formation in the Yarmouth area occurs in a synclinal structure with a predominantly metavolcanic core and metasedimentary and metavolcanic limbs, underlain by the Halifax Formation. The formation is divided into seven stratigraphic units composed of interbedded metavolcanic and metasedimentary rocks and commonly intruded by mafic dykes and/or sills which also occur in the adjacent Halifax Formation. The stratigraphically lowest unit (unit 1) consists of finely interbedded metasandstone and metasiltstone/phyllite with common quartzite lenses. This basal unit grades into a predominantly quartzite unit with finely interbedded phyllite near the base (unit 2). In its upper part, unit 2 grades into beds of massive quartzite. The third unit consists of metagreywacke, tuffaceous sandstone and mafic (lithic and crystal) tuff interbedded with quartzite near the base. Upwards, the unit becomes more pelitic, with staurolite schist, biotite schist, and garnet schist, as well as mafic tuff and flows. Overlying unit 3 is a sequence of finely interbedded metasandstone and phyllite overlain by mafic tuff and massive quartzite beds (unit 4). Higher in the sequence the unit contains schist and tuffaceous sandstone which grade into mafic tuff, flows, andesitic to felsic tuff (crystal and lithic), conglomerate and andesitic tuff. Above unit 4 is a predominantly mafic unit (unit 5) with basaltic flows and a mafic, coarse grained, amphibole-rich pegmatoid lens at the base. Mafic flows and tuff, as well as andesitic crystal and lithic tuff, occur at the top of the unit. On the eastern limb of the syncline unit 5 contains felsic crystal tuff (ignimbrite) interbedded with mafic and andesitic tuff. Unit 6 contains mafic tuff interbedded with

mafic lithic tuff which grades into predominantly metasedimentary (slate and metasandstone) beds on the eastern limb. This unit contains a subunit which is predominantly mafic tuff and flows. The stratigraphically highest unit in the syncline (unit 7) is predominantly metavolcanic and contains mafic tuff as well as possible flows. The Brenton Pluton occurs as a lens on the eastern limb of the syncline, intruding unit 1 of the White Rock Formation and in fault contact in the east with the Halifax Formation.

Petrographic and geochemical studies are currently in progress in order to improve lithological subdivision and metamorphic and tectonic interpretations. Petrographic analysis and field observation indicate that metamorphic grade increases from greenschist facies in the south to amphibolite facies in the north. Chemical data indicate within-plate, alkalic geochemical signature for the volcanic rocks and within-plate, A-type signature for the Brenton Pluton. Further work is in progress to investigate possible geochemical variations within and between stratigraphic units and lithologies. U-Pb dating of the ignimbrite in unit 5 is also in progress.

[1]Funded by the Nova Scotia Department of Natural Resources, a Natural Sciences and Engineering Research Council Grant to S. M. Barr, and an Acadia University Graduate Fellowship.

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An Overview of the Mining Industry in Nova Scotia

by ***M. A. MacDonald***, mamacdon@gov.ns.ca

The mining industry is a very important part of Nova Scotia's economy. The value of mineral production in Nova Scotia over the past decade (including petroleum) has ranged from approximately $450 to $650 million per year. Direct employment in the industry during this same period was between 3800 and 5600, with several times this number employed in supporting jobs. Average wages for the mining sector continue to be the highest for any provincial economic sector. A recent report by Statistics Canada noted that the average weekly salary was $792 for the mineral sector compared with $627 for transportation and communications and $641 for manufacturing. Where are these jobs? Most of them are located in the rural parts of Nova Scotia where jobs are needed most.

Nova Scotia has a rich mining history that spans over 300 years. The first gypsum mines in North America were located near Windsor. The first underground salt mine in Canada was located in Malagash near Tatamagouche. Coal was first mined in the Sydney coalfield by the French military in 1685. Sandstone from the Wallace area has been quarried since the early 1800s and was used in the Parliament Buildings in Ottawa. Barite has been mined in Nova Scotia since 1865. In fact, Nova Scotia produced the majority of Canada's barite from 1904 to 1920.

Nova Scotia gypsum production in 1998 was over 7 million tonnes, accounting for 80% of Canadian production and 7% of world production. Salt production in 1998 exceeded 1 million tonnes, representing approximately 7% of Canadian production. There are several large aggregate operations in Nova Scotia. The Martin Marrietta quarry in Auld's Cove produced 2 million tonnes of crushed rock in 1998 making it the 7thlargest rock quarry in Canada. In addition to the above commodities, several companies also produced coal, limestone, dolomite, barite, dimension stone and peat. Secondary, value-added processing of mineral products included cement, clay products (e.g. bricks), pharmaceutical barite, wallboard, salt products, sand and crushed stone and dimension stone products.

Lynx Minerals Corp. began mining their Scotsville barite deposit during the summer of 1999 and are currently producing mud-grade barite for use in the offshore oil and gas energy projects. Lynx also has plans to develop a large barite-fluorite deposit in eastern Lake Ainslie. **Georgia Pacific Corp.** has obtained conditional approval from the Environmental Assessment process and have submitted an application for a Mining Permit, for their proposed surface gypsum mine at Melford, Inverness County. The deposit has a combined proven and probable mineable reserve of 20 million tonnes of gypsum. **Tusket Mining Limited** and their international partner **Knauf,** have begun work at their Murchyville gypsum deposit in the Musquodoboit Valley. **Kaoclay Resources Inc.** continue to evaluate the economic viability of large kaolin and silica sand deposits in the Musquodoboit Valley and are currently conducting a

grid-drilling program. Kaolin is commonly used as a filler product in the paper making process. **Black Bull Resources Inc.** has completed an initial exploration program for their Flintstone Rock kaolin project in southwestern Nova Scotia. Additional work is planned to establish kaolin grade, tonnage and overall quality. **C_2C Mining Corporation** has announced plans to build a processing plant in the Annapolis Valley to process zeolites from their North Mountain deposits. **Nar Resources Ltd.** and joint venture partner **Titanium Corporation of Canada Ltd.** continue to explore for titanium-bearing sands in the Shubenacadie River, central Nova Scotia. The companies have conducted a close-spaced coring project to follow up on encouraging results from 1998. **Newfoundland Goldbar Resources Inc.** conducted a diamond-drilling project in 1999 to test the extent of gold at their Dufferin gold deposit.

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Overview of the Registry of Mineral and Petroleum Titles

by ***I. M. MacLellan***,.

The Registry of Mineral and Petroleum Titles is responsible for receiving applications for mineral and petroleum rights, and for issuing and registering licences and leases. In addition, documents affecting licences are registered by this office. The registry also receives statements of exploration expenditures and assessment reports that pertain to the renewal of licences and leases. Maps showing the disposition of lands under licence or lease are maintained and continually updated. The registry also maintains a system of Prospector Registration, including the issuance of prospector's identification cards. Applications for underground gas storage rights and treasure trove rights are also processed though this office. Information concerning production and employment in Nova Scotia's mines and quarries is received and compiled by the registry and published annually.

Staking Activity

Staking levels remained low for the first eight months of 1999 with approximately 440,000 acres under licence (new and reissued), down slightly from the same period a year ago. The normal pairing-down of larger ground holdings by companies, depressed gold and base metal prices, and the Asian crisis, were some of the factors which contributed to these low levels. One area, however, that did see an increase in staking activity was for salt and potash. The total area under licence for salt and potash rose from 5600 acres in 1997 to 29,840 acres in 1998 and currently stands at approximately 20,000 acres. The increased interest in salt and potash licences, a prerequisite for underground gas storage exploration, is driven by the Sable Offshore Energy Project. Reported assessment work expenditures totalled approximately $2.0 million for the first eight months of 1999, down moderately from the same period a year ago.

Mining Activity

In 1998, the estimated value of Nova Scotia's mineral production, including secondary mineral processing and crude petroleum totalled $468 million, a decrease of 11% from the year before. Excluding petroleum, the total value of Nova Scotia's mineral production totalled $347 million, down 15% from 1997's figure of $407 million. This decrease was due largely to lower outputs of coal, salt and construction aggregates. Coal sales dropped by approximately 22% in 1998 to 2.1 million tonnes from 1997's figure of 2.7 million tonnes as production problems continued to plague the province's largest coal mine, the Cape Breton Development Corporations's Phalen Colliery. Employment in Nova Scotia's mineral industry totalled roughly 3700 persons, a 3% decrease from the year before.

Demand for Nova Scotia salt declined by 28% in 1998 from 1997 primarily due to the re-activation in the fall of 1997 of Seleine Mines Inc.'s salt mine located on the Magdelen Islands. Seleine was forced to suspend operations there due to severe flooding in the Spring of 1995. With the completion of the Cobequid Pass (Highway 104 Western Alignment) in the fall of 1997, crushed stone production is estimated to have dropped by 28% in 1998 from 1997 to

roughly 6.2 million tonnes. On a positive note gypsum shipments, driven by a strong US economy, eclipsed the seven million tonne mark for the second consecutive year in 1998. The vast majority was shipped to wallboard plants along the US Eastern Seaboard. Cement shipments were up approximately 11% from a year ago.

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Mineral Exploration Activity in Nova Scotia

by ***P. D. McCulloch***, mccullpd@gov.ns.ca

The level of mineral exploration in Nova Scotia during the first nine months of 1999 has continued at approximately the same level of activity as in the previous three years. Overall, the level of exploration expenditures has demonstrated a general decrease over the past two years with field expenditures expected in the range of $4-5 million for 1999, compared with $5.6 million for 1998 and $6.7 million in 1997. Exploration was carried out for industrial minerals, base metals, gold and coal in a variety of geological environments. Highlights of exploration activities during the first nine months of 1999 are outlined below.

Exploration continued to focus on the exploration and development of industrial minerals including kaolin, silica sand, limestone, zeolites and barite. Kaoclay Resources Incorporated continued a detailed evaluation of Cretaceous kaolin and silica sand deposits in the Musquodoboit and Shubenacadie valleys of central mainland Nova Scotia. The company carried out extensive process testing on large-diameter core samples and completed additional diamond-drilling in the Middle Musquodoboit area. Black Bull Resources Incorporated, under an option agreement with CAG Enterprises Limited, began a detailed exploration program for kaolin in the Flintstone Rock area, Yarmouth County, including trenching and diamond-drilling. C_2C Mining Corporation is continuing a detailed evaluation of the zeolite potential of the amygdaloidal basalts along North Mountain in western Nova Scotia. The company completed geological mapping, diamond-drilling, and extensive analytical work on several properties in the area and recently carried out a bulk sampling program and process testing on a zeolite occurrence in the Stronach Mountain area. Nar Resources, under an option agreement with Titanium Corporation of Canada Limited, initiated a large-scale drilling program to evaluate the titanium potential of heavy mineral sands in the Shubenacadie River near South Maitland, Hants County. Exploration drilling for limestone was carried out during the year by Lafarge Canada Incorporated in the Hardwoodlands area, Hants County, and in the Brentwood area, Colchester County. Kelly Rock Limited completed additional work on the Glendale limestone deposit in Inverness County consisting of trenching and rock sampling.

Exploration for base metals focused primarily on areas of known mineral occurrences in several areas of the province. A diamond-drilling program was undertaken by Mount Cameron Minerals Limited in the Georges River and Mount Cameron areas of the Boisdale Hills in Cape Breton County. Savage Resources Canada Limited completed additional work on the company's Glenmore property in Halifax County and Geosearch completed detailed geochemical work on a base metal prospect near Lower Burlington, Hants County. Sikamen Gold Resources Limited initiated an exploration program for base metals in the Stirling area along the southwest extension of the Late Precambrian Fourchu Group in Richmond County.

The lower Paleozoic Meguma Group of southern mainland Nova Scotia continued to be a focus for gold exploration, although the number of exploration projects for gold dropped significantly in comparison to 1997. A diamond-drilling program was undertaken by Newfoundland Goldbar Resources Incorporated in the vicinity of the former Dufferin Gold Mine at Dufferin Mines, Halifax County. Indocan Resources conducted an exploration drilling program for gold on the North Star gold mine property at Isaacs Harbour, Guysborough County.

Exploration and development work for coal was undertaken in the Carboniferous rocks of northern mainland Nova Scotia and eastern Cape Breton Island. Berichan Resources Limited continued a detailed evaluation of coal resources in the Cottam Settlement area east of Debert, Colchester County, and began mining operations on the property in June, 1999. Brogan Mining Company Limited completed a bulk sampling program for coal at Little Pond, Cape

Breton County, early in the year.

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The Drill Core Library

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Exploration for economic mineral deposits often involves drilling holes into the bedrock to acquire better geological information and to obtain samples for examination or analysis.

Most exploration drilling is done using diamond-drills, so-named because the bits derive their cutting power from fine industrial diamonds impregnated into the cutting edges. The circular bit is attached to the end of hollow steel rods, which are rotated at high speed to cut a circular groove into the rock. The remaining core of rock stays inside the hollow rods and is recovered as "drill core." Holes are commonly drilled to, and continuous cores recovered from, depths of hundreds of metres. The drill cores are placed in sequence in wooden trays, which are labelled with hole numbers and depth markers, for later 'logging' (examination and description) and analysis. Normally the cores are split lengthwise with a diamond saw or a steel blade splitter prior to any destructive analysis so that one half can be preserved for future reference and further examination.

The purpose of the department's Drill Core Library in Stellarton is to preserve drill cores that are no longer required by mining exploration companies or others - diamond-drilling is expensive, and much valuable information can be obtained from existing drill core prior to embarking on further exploration work or geological surveys. We currently have about 650 000 m of core from more than 7000 holes drilled throughout Nova Scotia during the last 40 years. This core (and other sample materials) is available for examination at the Core Library by contacting Core Library staff in advance.

Staff at the Core Library have developed a database which is readily searchable to provide information about the core holdings. A database of most drilling done in the province is also maintained, so that information can be provided even if the core is not available.

The display gives some basic information on services provided at the Core Library, and demonstrates a number of representative sections of drill core from localities that are being highlighted during this conference. A computer is also on hand on which staff members will gladly perform searches for drillholes and drill core in areas of interest to you.

Core Library staff may be contacted by phone at 902-752-4842, by FAX at 902-755-7186 or by e-mail at mcmulljm@gov.ns.ca. Visit our web page at http://www.gov.ns.ca/natr/meb/one/dcl-home.htm.

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Macumber Formation Magnetic Signature in the (MacIsaac Occurrence) Bryson Quarry, Cheverie, Hants County, Nova Scotia

by ***R. F. Mills***, rfmills@gov.ns.ca

Decreasing North American availability of zinc and speculation in zinc future markets is re-igniting interest in the Carboniferous (Mississippian Windsor Group) Macumber Formation as a source of Walton-type mineralization. This is due, in part, to the scheduled closure of the Brunswick #2 Zn mine near Bathurst, New Brunswick, which is the largest operating Zn mine in the western hemisphere, as well as the recent closure of the Heath Steele base metals mine, an important regional producer, also in northern New Brunswick. Recent pipeline development in eastern Canada is also leading to onshore oil and gas exploration and there is increasing interest in the availability of barite for the purpose of servicing the local drilling industry. The Macumber Formation is documented to be the host rock of base metal and barite mineralization at Walton, Nova Scotia. This deposit has yielded 4.5 million tons of (90% $BaSO_4$) barite, 2.8 million ounces of Ag, and 2.8, 19.5 and 9.1 million pounds of Cu, Pb, and Zn, respectively (Boyle, 1972). The Walton deposit main quarry is currently identified as the largest deposit of barite in the world, with 900,000 tons of ore remaining in the deposit (Boyle, 1972).

Recent exploration in the Walton-Cheverie area of Hants County, Nova Scotia, is helping to provide new information for the geological map of the area. Exposure in the area is very poor, with less than 2% bedrock exposed. Position of the Macumber Formation is largely inferred from coastline bedrock exposures which often must be interpolated many kilometres into the interior of Hants County (Moore, 1982). Rock from the (Cheverie) Bryson quarry is used for local road and building fill. Recent enlargement of the quarry led to the discovery of a significant mineral occurrence (the MacIsaac Pb-Zn occurrence) described by O'Reilly (1997) in the Nova Scotia Department of Natural Resources Mineral Occurrence Database. While investigating this mineral occurrence further in 1999, rocks in the quarry were positively identified as Macumber Formation, placing position of this important host rock several kilometres from its inferred position.

A proton magnetometer survey was conducted in 1999 with the intention of helping to provide important data on the signature of mineralized rocks in this terrane in general, and the Macumber Formation in particular. The Bryson quarry survey reveals a background signature for the several rocks seen in the pit, which are oriented roughly east-west. The signature is complicated by a zone of partial magnetic depression in the vicinity of the quarry. Marked magnetic highs are noted where rocks occur close to alteration associated with a partially stratabound, dioritic body mapped in the quarry. However, some highly localized magnetic highs are correllatable along roughly a north-south orientation. These data are interpreted to be faults oriented normal to the strike of rocks in the quarry area. Data from this, and other surveys, will help to provide information for recognizing and tracing a Macumber Formation signature when prospecting for base metals and barite in this important terrane.

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The Geology, geochemistry, and origin of the barite, manganese and lead-zinc-copper-silver deposits of the Walton-Cheverie area, Nova Scotia; Geological Survey of Canada Bulletin no. 166, 181 p.

Moore, R. A. 1986:
Geological Map of the Windsor Area, Nova Scotia; Nova Scotia Department of Natural Resources, Geological Map 86-02, scale 1:25 000.

O'Reilly, G. A. 1997:
MacIsaac Pb-Zn-Ba Occurrence; Nova Scotia Department of Natural Resources, Mineral Occurrence Database, Occurrence #H01-049, 3 p.

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Ground Geophysical Signatures of the Mineralized Macumber Formation and the Tomlinson Mine

Occurrence, in the Walton-Cheverie Area, Hants County, Nova Scotia

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Surprisingly little has been published regarding local ground geophysical signatures for the mineralized Macumber Formation in the vicinity of the base metal and barite deposit at Walton, Nova Scotia. This major deposit has yielded the bulk of base mineral production from Hants County, Nova Scotia (4.5 million tons of 90% $BaSO_4$, 2.8 million oz. Ag, 1.3 million kg. Cu, 9.5 million kg Pb and 4.4 million kg Zn) (Boyle, 1972). The area remains one of the most important base metal exploration targets in Nova Scotia.

Several lines were surveyed in the vicinity of the Walton Mine to provide information for the purpose of recognizing a Macumber Formation signature when prospecting for this important host rock, since position of the Macumber Formation is largely inferred and exposure in the area is very poor (Moore, 1982). The signature information is compared to signature information for a grid drawn in the immediate vicinity of the Tomlinson mine area, (Hughes, 1995). This mineral occurrence, approximately 3 km south of the Walton mine site, has been recently enlarged, revealing further abundant, massive, Fe-Mn deposits in north-trending fractures in Horton Group sediments.

A proton magnetometer survey and VLF-EM survey was conducted in 1999 over the Tomlinson area, as well as several cross-sections in the vicinity of the Walton mine for comparison, and with the intention of providing important data on the signature of mineralized rocks in this terrane in general and, the Macumber Formation in particular. Rocks in the area of the Walton mine do not exhibit a signature that can be positively correllated with the Tomlinson vicinity. Data from the Tomlinson area are stronger, owing to the lesser degree of overburden associated with the local surficial geology. However, data from the Tomlinson site delineates north-trending anomalies coincident with mineralization in the area. Data from this, and other surveys, will help to provide information for recognizing and tracing the signatures of structures that may be important constituents of base metal mineralization models for this important terrane.

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Tomlinson mine occurrence; Nova Scotia Department of Natural Resources, Mineral Occurrence Database, Occurrence #H01-0001, 2 p.

Moore, R. A. 1986:
Geological map of the Windsor area, Nova Scotia; Nova Scotia Department of Natural Resources, Map 86-02, scale 1:25 000.

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Isopach Contour Drawings of Diamond-drill Hole Data in the Fall Brook-Maple Brook Area of Kings County, Nova Scotia

by ***R. F. Mills***, rfmills@gov.ns.ca

The area around Fall Brook has been of interest as a possible source of paleoplacer gold since the early 1860s, when a small operation exploited gold in cemented Horton Group sediments at the Horton Group-Meguma Group contact in the Fall Brook canyon. Several assays of Horton Group sediments in 1998 returned anomalous gold levels in coarse-grained quartz pebble conglomerates perched well above the Meguma contact, in Maple Brook. These rocks are laterally equivalent to those found at Fall Brook.

Data from a series of diamond-drill holes drilled in 1982 by Saarburg Interplan are being examined, as well as the core from these holes, to investigate possible paleoplacer gold target areas. Some of the original core, in storage at the Nova Scotia Department of Natural Resources core facility in Stellarton, is being analyzed for gold. Several assays have returned levels in the order of 0.7 to 1.4 ppm Au.

Stacked isopach drawings of the lithological contact isograds have been drawn from drillhole log data. These drawings are helping investigators interpret possible deposition sites and ancient canyons in the Fall Brook-Maple Brook area. Today, the topography of the area drains north, to collect in Lebrun Brook and drain west to the Avon River in several channels which drain the area in a dendritic pattern. At the time the Horton Group was laid down, there was a single deep channel, draining the area to the north and west, which dominated the Fall Brook-Maple Brook area. Topography developed through the Carboniferous, and deposition of the Windsor Group closer to today's landscape, which is obviously influenced by glacial overburden as well. This study will be expanded in the future to include diamond-drill holes farther west, and should give a clearer picture of the deposition pattern of Horton Group rocks and the development of possible channel sources of paleoplacer gold.

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Geochronological Constraints on the Evolution of the St. Marys Basin, Central Mainland Nova Scotia

by ***J. B. Murphy***, bmurphy@stfx.ca, Department of Geology, St. Francis Xavier University, Antigonish, Nova Scotia, Canada B2G 2W5, and ***M. A. Hamilton***, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada K1A 0E8

The St. Marys Basin, central mainland Nova Scotia, lies along the southern flank of the composite late Paleozoic Magdalen Basin in the Canadian Appalachians and along the Avalon-Meguma terrane boundary, which is defined by the E-W Minas Fault Zone. The basin fill consists of Late Devonian - Early Carboniferous continental clastic rocks of the Horton Group that were deposited in fluvial and lacustrine environments after the peak of the Acadian orogeny.

SHRIMP (super high resolution ion microprobe) II GSC data for approximately 100 detrital zircons from three samples in the Horton Group show that most of the zircons have been involved in a multi-stage history. Although there is a minor contribution from Early Silurian (411 Ma) and Late Devonian suites (ca. 380-370 Ma), most detrital zircons are recycled from clastic rocks in the adjacent Meguma and Avalonian rocks. Neoproterozoic (ca. 700-550 Ma) and Paleoproterozoic (ca. 2.0 to 2.2 Ga) zircon populations predominate, although there is a minor contribution from ca. 1.0 Ga, 1.2 Ga and 1.8 Ga zircons.

U-Pb single zircon analyses on clastic sedimentary rocks of the Meguma and Avalon terranes (Krogh and Keppie, 1990; Keppie et al., 1998) show these terranes have different populations of detrital zircons, suggesting they are sourced from discrete portions of the ancient Gondwanan margin. Both terranes contain Neoproterozoic and Late Archean populations. However, Avalon terrane rocks also contain important Mesoproterozoic zircons between 1.0 Ga and 1.8 Ga.

The SHRIMP data, in conjunction with published sedimentological and geochemical data, indicate that the Horton

Group basin fill sediments are largely the result of uplift and erosion of Meguma terrane metasedimentary and granitoid rocks immediately to the south of the St. Marys Basin during the waning stages of the Acadian orogeny. Regional syntheses indicate that this uplift occurred before and during deposition and was a consequence of dextral ramping of the Meguma terrane over the Avalon terrane along the southern flank of the Magdalen Basin.

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Surface Mining of Coal in Nova Scotia: Challenges and Innovations

by ***R. D. Naylor***, rdnaylor@gov.ns.ca, ***J. F. Campbell*** and ***P. J. Hannon***

Coal will continue to be an important short- to medium-term fuel source for electrical power generation in Nova Scotia. However, if the province's underground coal mines continue to have geotechnical difficulties we may no longer have a secure supply of indigenous coal. One bright spot in the midst of this uncertainty is the continued interest in surface mining of coal in Nova Scotia. Currently there are nine surface coal mines operating in the province. These mines are in various states of operation from advanced permitting to reclamation. The largest of these mines, operated by Pioneer Coal in the Stellarton area, will have an approximate life span of 10 years.

Surface coal mining is an important source of economic development for a number of Nova Scotia communities. In addition to the obvious economic benefits, surface mining often plays an important role in ultimately improving land value. Many of the province's surface mine sites are situated on lands that contain abandoned mine openings and waste piles associated with old underground mining operations. Typically these lands are unsafe for travel or construction and, therefore, represent a liability to the owner. Surface mining and subsequent reclamation actually removes these risks and thus significantly improves the value of the land. Recent advances in mining technologies, such as highwall mining systems, should further enhance opportunities for surface mining of coal in Nova Scotia. Highwall mining systems are capable of remote mining of coal up to 300 m from an entry. This results in a dramatic reduction in the amount of land that needs to be disturbed prior to extraction of the coal.

The Nova Scotia Department of Natural Resources (NSDNR) has played an important role in encouraging development of surface coal mines in the province. From the early 1970s to the early 1990s the department undertook an extensive coal inventory program. Evaluation of coal resources that could be recovered by surface mining was an important part of this program. Potential sites were typically mapped and then diamond-drilling was used to evaluate coal quality and tonnage. In addition, detailed evaluation of the strata overlying the coal was undertaken to help determine the mineability of the resource. Staff from NSDNR are currently undertaking follow-up studies on some of the new surface coal mines. Emphasis is being placed on collecting geological information that can help mine operators with their mine planning and operations. Staff are also assessing opportunities to reclaim historic mine sites through the recovery of the remaining coal resources.

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"Boy that Public Meeting Cost a Lot, Was It Worth It?" A Critical Examination of Pre-development Activities and Their Value as They Relate to Mine and Aggregate Developments

by ***P. G. Oram***, Project Manager/Geologist, MGI Limited, Dartmouth, Nova Scotia

The costs associated with public consultation, community involvement, permitting and environmental baseline studies are often perceived as major impediments to mine development. Much of this perception is based on the dollar figures associated with high profile, large-scale projects. In some cases these are difficult projects to evaluate due to uncertain costs/benefits (social, economic and environmental) for communities, First Nations Peoples, focused interest groups and regulators, which add costs associated with public consultation and permitting. The costs associated with this pre-development work can be significant when looked at as simply line items in the project cost spreadsheet; however, with respect to the percentage that these pre-development costs represent in the overall costs for development the number is sometimes very small.

This presentation examines a number of pre-development activities and critically examines the cost/benefit relationship for each activity. Included in the presentation is comment on the use of pre-development activities in reducing overall costs for mine development by moving the completion time frame for these activities closer to the exploration phase than the development phase. The presentation uses comparisons between the real pre-development costs and overall project costs associated with several different mine and aggregate developments such as:

1. a large-scale surface gypsum mine development which was screened out of the federal Environment Assessment process and evaluated by the provincial process;
2. a small-scale surface coal mine development which was screened out of the federal Environmental Assessment process and evaluated by the provincial Environmental Assessment process, except for a portion of the project which required federal involvement for a stream diversion;
3. a large-scale surface and underground lead/zinc mine re-development, which is being reviewed by a joint federal and provincial Environmental Assessment process; and
4. a small-scale pit and quarry development which was screened out of the federal Environmental Assessment process and evaluated by the provincial Environmental Assessment process.

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Mineral Inventory Activities 1999

by ***G. A. O'Reilly***, gaoreill@gov.ns.ca, and ***G. J. DeMont*** gjdemont@gov.ns.ca

The Department of Natural Resources recognizes the importance of providing fundamental geological information to our clients on mineral occurrences found within the province. The Mineral Inventory Program does this by maintaining the Mineral Occurrence Database, a computer database of information on metallic and industrial mineral occurrences. The database, although designed primarily with mineral explorationists, prospectors and GIS applications in mind, also serves many other clients. Geological mappers, research geologists, other government departments, environmental consultants, land-use planners, rockhounds, mineral collectors and the public in general all make use of our database.

The Mineral Occurrence Database is maintained in FoxPro® for Windows® Version 2.6 and currently has 1,168 metallic and 851 industrial mineral occurrences. Updates of the database are carried out twice yearly. The database provides information such as occurrence name(s), location (UTM and lat. and long.) commodities and minerals present, exploration history and other fundamental geological information. The Mineral Inventory Program has created a computer query program for easy, menu-driven access to the Mineral Occurrence Database. The program is self-installing and allows easy access to the database for viewing, search and printing of information. The program and database are available free-of-charge on the Branch Internet site (URL http://www.gov.ns.ca/natr/meb/index.htm) or at minimal cost from the department's library.

Field checking of mineral occurrences and research and verification of existing information prior to inclusion in the database are the most important components of the Mineral Inventory staff duties. During the last year field verification of mineral occurrences in the eastern shore region and in central and northern Cape Breton continued to be a priority. In Cape Breton, field activities concentrated in the Barachois River-Indian Brook region and focused on

several interesting Au-Ag-Te occurrences. In addition, emphases was placed on including information for a number of significant industrial mineral occurrences on NTS map areas 11F/14 and 11K/01. The Eastern Shore region contains the majority of the past-producing gold districts and significant prospects for which the Meguma Group is well known.

Several other mineral initiatives were attended to by Mineral Inventory staff during the year. G. J. DeMont and Industrial Mineral Geologist P. W. Finck have been providing advice and field support on several red marble and limestone prospects in the Kennedy and Diogenes Brook areas of Cape Breton to a consortium consisting of the Strait Highlands Regional Development Agency, Nova Scotia Department of Economic Development, and Enterprise Cape Breton. G. A. O'Reilly provided field support as part of a co-operative effort between ASEDEX Minerals Corp. Ltd., Dalhousie University Earth Sciences Department, College of Geographic Sciences, Geological Survey of Canada, and the Department of Natural Resources on the metasediment-hosted Eastville Zn-Pb Prospect. O'Reilly also carried out an examination of garnet gneiss units within the Liscomb Complex southwest of Trafalgar, Guysborough County, for their potential as a source of industrial garnets.

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Aggregate Program

by ***G. Prime***, primega@gov.ns.ca

Mineral aggregates in Nova Scotia consist primarily of sand, gravel and quarried stone. Collectively these materials are required in all aspects of construction and are a fundamental component of our modern infrastructure. More than 10 million tonnes of this nonrenewable resource are consumed annually in the province.

Although billions of tonnes of aggregate exist today in deposits scattered throughout Nova Scotia, this should not be interpreted to mean an unlimited supply of aggregate for the future. Several factors severely restrict the availability and usage of much of this resource. First, many of the deposits will not meet the rigid materials standards demanded today in the construction industry. Second, high transportation costs associated with delivering the product to market make many remotely located aggregate deposits economically inaccessible. Third, economic development and urban sprawl have resulted in competition for the land and land-use conflicts. The result is sterilization of many aggregate deposits and opposition to the permitting of new aggregate operations in some of the populated areas. Fourth, restrictive land uses, such as parks and protected spaces, have removed large blocks of land from extractive resource use. Collectively these factors severely shrink the resource base, making the sourcing of high quality aggregate more difficult for the producer and more costly for the consumer. If the resource land is left unprotected, aggregate potential may disappear in many of the areas where it is needed most.

In recognition of the growing concerns for the resource, an aggregate program was established by the Mines and Minerals Branch more than two decades ago. Today the primary goals of the program are

1. to identify and evaluate the aggregate resource throughout the province and
2. to promote its protection for the future.

The current project, initiated in 1995, is an examination of the Annapolis Valley region and comprises Hants, Kings, Annapolis, Digby and Yarmouth Counties. It consists of field mapping the surficial and bedrock aggregate potential and a limited sampling program. The focus of the 1999 field season was the completion of Hants and Kings Counties and included parts of NTS map areas 11E/3, 11E/4, 11E/5, 11D/13, 21A/10, 21A/15 and 21A/16. Approximately 3500 site descriptions have been compiled for the project to date. This includes pits, quarries, and a variety of other surficial and bedrock exposures. Materials documented include sand, gravel, till, clay, residuum, talus and bedrock. The field component of the project has also provided the opportunity to examine the geology for other industrial mineral opportunities, such as clay and dimension stone. The point data as currently being entered into an ArcView® database. Air photo interpretation of Hants and Kings Counties will be conducted in early 2000. Digital maps at a

scale of 1:50 000 for each county will be released as they are completed.

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Biogeochemical Cycle of Trace Elements, Notably Hg in Kejimkujik National Park, Nova Scotia

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Kejimkujik National Park is known to have elevated levels of mercury in biota, particularly loons which bio-accumulate Hg from the system. An ongoing study is investigating the potential sources (natural and anthropogenic) and processes that may contribute to these elevated levels. This report will cover a component of the study, which has looked at multi- media sampling of vegetation, rocks and lake waters.

Fifty lakes were sampled and waters analyzed for trace elements and levels of dissolved organic carbon (DOC). Red maple, white pine, hemlock and white birch were sampled at 53 sites and tissue was analyzed for trace elements. One hundred and eighteen surface rock samples were taken from various rock types in and adjacent to the park.

The Hg concentrations in trees are comparable to levels in the literature (Rasmussen, 1994). Mercury concentrations in the leaf tissue showed a 5 fold range in values; which is attributed to site differences as samples were from the same species, same tissue, same height, and samples were gathered over a narrow time window (5 days). Similarly the mercury (total) levels in lake waters were comparable to levels in the literature (Beauchamp et al., 1997) and for other values at Kejimkujik Park (Clair et al., 1998). There is also a five fold range in the Hg levels for lake waters, which is attributed to site differences as samples were taken using the same protocol at each site and sampling was limited to a two day period. The levels in the rocks appear relatively low but are comparable to levels in the literature (Rose et al., 1979). There is a wide range in the levels and this is directly related to the mineralogy of the rock sampled. Also, regional lake sediment surveys indicate anomalous levels of Hg over the South Mountain Batholith. Coincident with the high levels of Hg in these lakes are relatively high concentrations of Hg in perch. The pH values in the lake waters varied from 4.1 to 6.2.

It is potentially significant that the level of Zn in the underlying rocks is related to the Hg levels in fish. This could indicate a relationship with mercury-bearing minerals, a link with sulphide minerals, and its relationship with lake pH or a combination of these attributes. Although little is known of their mercury geochemistry, the rocks are rich in arsenic and locally zinc and gold - all elements that tend to occur with mercury in natural environments. Unpublished results for a drillhole (26 samples) near Clarksville, Nova Scotia, illustrate a clear association of mercury with the levels of zinc and arsenic.

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Dalhousie University: Department of Earth Sciences Student Research in Nova Scotia

by ***P. H. Reynolds***, Chair, Dalhousie University, Halifax, Nova Scotia B3H 3J5; Phone 902-494-2358, or check us out at http://meguma.earthsciences.dal.ca/

Dalhousie University in Halifax is well situated and well equipped for research in a range of Earth Science disciplines. The department includes 12 full-time faculty members and 6 university technicians, with 13 Ph. D., 8

M. Sc. and 11 B. Sc. honours students (final year) registered in 1999-2000. The department offers research projects in petrology and geochemistry, sedimentary geology, micropalaeontology, tectonics, structural geology, and in thermochronology (argon, fission track and thermal luminescence/optical dating). Many faculty members and their students are involved in research in Nova Scotia or its adjacent continental margin. Research is funded largely through the Natural Sciences and Engineering Research Council (NSERC), other government agencies, and contracts; most graduate students hold scholarships or fellowships paid from University and/or research funds.

Research equipment includes a JEOL 733 electron microprobe with image analysis system (run as a regional facility); geochronology laboratories:

i. conventional and laserprobe $^{40}Ar/^{39}Ar$ dating,
ii. thermally and optically stimulated luminescence (TOSL) research,
iii. fission track research; X-ray diffraction equipment, a high pressure seismic velocity lab, a paleomagnetism lab, and a wide range of geophysical, sedimentological, micropaleontological, computing, petrographic, sample preparation, and photographic equipment.

Theses Completed 1999

John P. Brown (Ph. D.) 1999. Deformation and sedimentation adjacent to Carboniferous diapiric salt structures, Nova Scotia.

Donald L. Fox (Ph. D.) 1999. Prediction of acid rock drainage (ARD) from sulphidic slates using GIS analysis of mineralogical, geochemical, magnetic and geological parameters: a test case in southern Nova Scotia.

Tammy L. Allen (M. Sc.) 1999. Sedimentology, sequence stratigraphy, and source-rock potential of the Upper Carboniferous Colindale Member, Port Hood Formation, Western Cape Breton Island, Nova Scotia.

Richard J. Horne (M. Sc.) 1999. An evaluation of flexural-slip folding in the Meguma Group, Halifax and Ovens areas, southern Nova Scotia.

Gavin K. Manson (M. Sc.) 1999. Recent and historical coastal change under rising sea level, McNab's Island area, Halifax, Nova Scotia.

Craig C. Atkinson (B. Sc.) 1999. Morphological changes in Chezzetcook Inlet: a historical study using air photography composites.

Melanie Oakes (B. Sc.) 1999. Alluvial fan deposits of the Carboniferous Grantmire Formation in Drillhole PE 83-1, Sydney Basin, Nova Scotia.

Anne-Marie J. Whittaker (B. Sc.) 1999. Experimental evaluation of subaqueous disposal of acid-generating sulphide minerals in the Meguma Supergroup, southern Nova Scotia.

Michelle Lee Williamson (B. Sc.) 1999. Reconstruction of pollution history at Mill Cove, Bedford Basin, using benthic foraminifera.

Graduate Thesis Research Underway

S. Carruzzo (Ph. D.): Ore deposits in the New Ross area.

D. Johannessen (M. Sc.): Groundwater in the Avon River Valley.

A. M. Ryan (Ph. D.): Radioelements (radon, uranium) in Nova Scotia.

R. Tobin (Ph. D.): Use of foraminifera as pollution indicators.

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New Digital Map of the Surficial Geology of Central Nova Scotia

by ***R. R. Stea***, ***S. E. Pullan***, Geological Survey of Canada, Minerals and Continental Geoscience Branch, 601 Booth Street, Ottawa, Ontario K1A 0E8, and ***C. Jessome***

This new digital map product is a prototype for a planned series of Mesozoic-Cenozoic geology (surficial) maps covering the drift-covered lowlands of Nova Scotia. The map will integrate sample site databases with objective information on site geology and geochemistry with interpretive maps. The databases and maps will provide three dimensional information on these lowland basins from underlying bedrock geology to the structure and stratigraphy of unconsolidated Mesozoic and Cenozoic deposits that reach 300 m in thickness. The surficial databases include:

1. Site descriptions from present and previous geological and geochemical surveys.
2. Site sample databases including grain size analysis, geotechnical data, geochemical data.
3. Water well logs with stratigraphy, accurately located in the field using GPS.
4. Geotechnical-Department of Highways and Environment drill logs with detailed information on surficial deposits at depth.
5. Department of Natural Resources and mining industry surficial drill logs.
6. Seismic reflection profiles and test site data.

These data will be integrated with maps showing the nature and distribution of glacial deposits and hidden Mesozoic valleys. These data are all presented on an ArcView® platform with legends, and mini-reports on the geology of each major rock unit, in HTML format, readable with a standard NETSCAPE browser. The data will be useful to clients in the mining industry, agriculture, civil and environmental engineers, hydrologists, planners and anyone else needing detailed 3-D geological information on the surficial geology of populated lowland areas.

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Research Activities at the Centre of Geographic Sciences Remote Sensing/GIS Research Group

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The Centre of Geographic Sciences obtained 17 scenes of Radarsat-1 imagery from the Nova Scotia Geomatics Centre in late 1996. In order to use the images effectively in a GIS environment or integrate them with other datasets to produce hybrid images (e.g. radar and elevation or radar and geophysics), they must be geocoded. In order to properly rectify a SAR image a Digital Elevation Model (DEM) must be used to orthorectify (geocode) the imagery and compensate for the inherent distortions in SAR imagery. These radar images have been used to construct a provincial mosaic. The mosaic has been colourized by elevation derived from the 1:50 000 NTS maps to take advantage of chroma-stereoscopy technology and when viewed with ChromaDepth™glasses produces a 3-D image of the terrain. A cartographic overlay of major roads and towns has been placed over the colourized radar mosaic.

Recently this hybrid image has been colourized by provincial geophysical datasets including Bouguer gravity, total field and vertical gradient magnetic data allowing visual correlation between surface topography and subsurface characteristics such as density or magnetic minerals.

In October of 1999 the Space Shuttle will embark on the 11 day "Shuttle Radar Topographic Mission (SRTM)." The mission will acquire high detail elevation maps for the entire world, from 60°N to 60°S. COGS has been awarded a research project to validate the elevation maps coming from this mission for parts of Nova Scotia. This will be done by comparing the shuttle DEMs to current elevation models within a Geographic Information Systems (GIS) at the Centre and using the Global Position System (GPS) equipment at COGS to very accurately define several point positions. In addition to the elevation data we are also receiving radar imagery that will be used to build information products of the terrain and used in research to compare to Radarsat, Canada's Earth observation radar satellite. The SRTM is a joint project between NASA, the US National Imagery and Mapping Agency (NIMA), and the German and Italian space agencies. The German Aerospace Centre (DLR) will supply COGS/NSCC 20 products for various parts of Nova Scotia and in return we will present the results of our research. Elevation data are important in many engineering projects or environmental impact assessments, and can be used for pipeline routing, slope calculations, watershed delineation, drape satellite imagery over elevation for assisted interpretation and planning. The radar imagery provides an image of the earth regardless of fog or cloud and highlights topography and land-use patterns.

These datasets along with those existing at COGS will be used as part of a new Applied Research Initiative underway at COGS. We will be embarking on a project in excess of $2M to collect and analyze data in the coastal zone. Aspects of the project include deriving DEMs from a variety of sources (photogrammetry, stereo satellite coverage, airborne LIDAR and interferometry, etc.) And validating them using DGPS. Also several remote sensing systems will be used to map landcover including optical and SAR imagers. Applications of these data include flood risk mapping, geoscience mapping, wildlife habitat mapping and others.

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Characterization of Minor Folds in Buckled Coticule Layers within the Beaverbank Member, Central Nova Scotia

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Minor buckling of coticule layers has been evaluated within the Beaverbank member, the lowermost unit of the Halifax Formation of the Meguma Group, in the Fall River - Mount Uniacke area. Minor folds are common features of regional scale folds and may be useful in understanding their strain history. Such folds can develop prior to regional folding, or may have a syn-folding origin. Determining the relationship of minor folds to regional folds in the Meguma Group is complicated by the box fold character of regional folds, where considerable hinge migration during fold development must have occurred.

Field observations indicate disharmonic and polyharmonic buckling that is well developed in coticule layers, reflecting the high competency contrast with the slate host. Fold geometries of buckled coticule layers include ptygmatic, box fold, and S-Z-M fold geometries, and all demonstrate significant shortening. In some instances mesoscale box-folded coticule layers are characterized by straight limbs and tightly folded flat hinge segments. Fold profiles of buckled coticule layers vary considerably along strike over short distances, reflecting noncylindrical fold geometry. Buckled coticule layers occur both in the hinges and on the limbs of some regional folds. In some instances straight (non-folded) coticule layers occur with buckled coticule layers on regional fold limbs, whereas in other instances no buckling of coticule layers occurs on regional fold limbs. Cleavage around buckled coticule layers is characterized by a divergent pattern around minor fold hinges, indicating only minor cleavage formation prior to

buckling. Where buckled coticule layers on regional fold limbs have a box fold geometry, cleavage in the surrounding slate is axial planar to minor folds; however, it does not generally parallel regional axial planar slaty cleavage. In regional fold hinges cleavage around buckled coticule layers is axial planar to both the minor and regional folds.

The observed minor fold geometries and related cleavage do not always illustrate a relationship consistent with regional folds. This may reflect the relative timing of buckling of the coticule layers with respect to regional fold development. This includes the involvement of hinge migration during regional fold development, where early regional fold limbs may now be located in fold hinges and early regional fold hinges may now be located on fold limbs.

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